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THE LIVING SUBSTANCE—A THEORY.

Die Biogen-hypothese. By Prof. Max Verworn. Pp. iv+114. (Jena: Fischer, 1903.) Price 2.50 marks.

THE author of the well-known work on "Allgemeine Physiologie" is always interesting in his physiological writings, whether one admits the validity of his conclusions or not; and the volume before us, though highly speculative in its nature, cannot fail to attract attention, no less on account of the intrinsic importance of the subject than by reason of the lucidity with which a difficult topic is handled.

The Biogen-hypothese is nothing less than an attempt to frame a working hypothesis that shall render intelligible the *modus operandi* of a living organism and to explain in a comprehensive manner the general nature of the physical and chemical processes involved. Such an explanation, as the author himself insists, can only be regarded as a temporary expedient in the present condition of our knowledge, but the author of a theory or hypothesis is amply justified in propounding it if he is enabled thereby to indicate definite lines of investigations, whatever the influence the results thereby obtained may exercise on the theory itself.

The various hypotheses that have been put forward to account for the facts of metabolism are briefly discussed and the nature of the respiratory process is specially considered. It seems quite clear from the results of numerous investigators that whatever the nature of the sequence of chemical events, the carbohydrates are proximately the substances that are most intimately affected. These carbohydrates might be derived directly from the store of accumulated reserve products, or an analogous atom group might be split off from the more complex proteid-like bodies. On the whole, the latter seems the more probable view, and thus dissimilation and assimilation form a constantly oscillating series of phenomena that give rise to the processes described as metabolism.

The biogen is regarded by Verworn as a real chemical or physical entity, consisting of various groups of atoms held together round a central benzene nucleus. Dissimilation, or katabolism, occurs when certain atom-groups are split off from the biogen, and normally these represent carbohydrates or some similar bodies, a view which is by no means new and one that finds support, for example, in the behaviour of muscle when it is made to do work. For it is well known that the excessive amount of carbon dioxide excreted in such circumstances is not accompanied by a correspondingly increased excretion of nitrogenous waste-products. On the contrary, the nitrogenous remainder of what Verworn terms the biogen regenerates itself by seizing upon the available sugars or other carbohydrates. A distinction is drawn between this "functional" dissimilation and the "destructive" dissimilation that follows on extreme starvation; for in the latter case the nitrogen-containing remainder of the biogen undergoes further decomposition, and then the simpler groups thus produced no longer possess the faculty of regeneration at all and so are unable to reproduce the living substance once more.

As to the cause of the lability of the biogen, Verworn strongly champions the view that it is the result of the incorporation of oxygen in the molecule, and that when irritability ceases, on arresting the supply of this gas, it is not due to the possible inhibitory action of the accumulating waste products, but that in the absence of oxygen the conditions of adequate lability are not provided. The arguments are largely based on the behaviour of frogs that have been poisoned by strychnine and in which an artificial circulation by means of salt solution is maintained. This can be so arranged as to provide or withhold oxygen from the tissues. In the latter case, stimulation ceases to excite contraction in the muscles, though on readmitting oxygen, tetanus is easily produced on the application of suitable stimuli. If a long interval of time is allowed to elapse during which no food is being conveyed to the tissues, starvation, and consequent reduction in the number of labile biogens, ensues. Hence stimuli gradually provoke weaker and weaker responses. If once more the supply of oxygen is cut off, loss of excitability again supervenes, but this passes away again on readmission of oxygen. Verworn seems to conclude that because this return of excitability recurs at once, both in the unstarved and starved tissue, the inhibition effect of the deprivation of oxygen cannot be ascribed to the accumulation of waste products, since in the former case this should have been of much greater magnitude in correspondence with the much larger amount of waste substances, and, therefore, the *rôle* of the oxygen must have been that of a labilising agent, directly producing the condition for explosive decomposition in the active biogens. But it is not shown whether the influence of waste products upon the hypothetical biogens may not be a proportionate one, in which case there would be perhaps no very obvious reason why any difference should be looked for in the two cases. Moreover, it is quite clear that the free oxygen does oxidise harmful waste products and reduce them to a form (*e.g.* carbon dioxide and water) in which they may be either innocuous or at least readily escape from the tissues. The accumulation of alcohol in plant tissues in the absence of oxygen is a case in point, and readmission of oxygen has the immediate result of increasing the output of carbon dioxide at the expense of the alcohol abnormally present in the tissues.

The biogen hypothesis gives a plausible account of growth and the production of fresh living material by supposing that the molecule is capable of polymerisation and then of falling into simpler substances once more. But this view would seem further to imply that the more highly polymerised bodies do not differ essentially in their properties from the more simple ones. In endeavouring to locate the seat of the biogens in the cellular organisation, it is concluded that they exist in the cytoplasm but not in the nucleus. The evidence for this is based on observations adduced to show that enucleated protoplasm can exhibit metabolic activity, and further, that the oxidative charges are more especially obvious in the cytoplasmic, rather than in the nuclear, constituents of the cell. But perhaps one may reasonably question the

advisability of endeavouring to go so far. We are as yet far too ignorant of the nature of the relations existing between cytoplasm and nucleus to be able to draw any safe general conclusions respecting them. What we do know suffices to prove that, probably as the result of interchange of material, the relations are at least of a very intimate nature.

It is, of course, impossible within the limits of so short a notice to attempt to do anything like full justice to the skilful treatment that Prof. Verworn has brought to bear on his subject. It must suffice to repeat that it is thoroughly well worth reading, and whatever may be thought of the tenability of the hypothesis itself, one can hardly deny that it does fulfil the important condition of enabling one to link together in a suggestive manner a large number of very complicated phenomena.

SCIENCE AND PRACTICE.

The Lighthouse Work of Sir James Chance, Bart. Pp. x + 162. (London: Smith, Elder and Co., 1902.) Price 5*s*. net.

THE optics of lighthouse lenses form a sufficiently fascinating subject, and its interest, apart from its practical importance, has attracted able men from Augustin Fresnel down to John Hopkinson. Among these, James Timmims Chance deservedly holds a prominent place, and his biographer has earned our thanks by the account he has given in the pages under notice of Chance's life and work.

Sir James Chance, a son of Mr. William Chance, of Birmingham, one of the partners in the glass-making firm of Chance Bros. and Co., was born in 1814. After gaining honours in various subjects, including Hebrew, at University College, London, he entered Trinity College, Cambridge, and in 1838 he graduated as seventh wrangler. Immediately after this he entered his father's firm, of which he remained a partner for fifty years, being head of the firm for twenty-five. He was made a baronet by her late Majesty on the occasion of her last distribution of birthday honours. He died on January 6, 1902.

In old days, parabolic reflectors were used for lighthouses; the employment of lenses is due to Augustin Fresnel, who in 1819 erected the first dioptric system at the Tour de Cordouan; the system was extended by his brother Leonor and other distinguished men in France, and in Great Britain by the family of Stevenson, by Airy and by Faraday. With the two latter Mr. Chance became intimately associated about the year 1859.

His firm had manufactured lighthouse lenses for some years previously. Before this, the industry had been crushed out in England by Excise regulations; an Order in Council was required to permit of their manufacture, and a duty amounting to some 300 per cent. on the cost of the glass was enforced. In consequence, Messrs. Swinburne and Co., of South Shields, who for a few years had manufactured lenses, gave up the work in 1845. In 1850 Messrs. Chance took it up. They engaged a French expert, M. Tabouret, who had worked for Fresnel himself, and he exhibited in the Exhibition of 1851 an apparatus of the first order, made at Messrs. Chance's Spon Lane works. In the years that followed, the work prospered, the plant was increased and the optical part of a number of lighthouses was manufactured. M. Tabouret left the firm in 1853.

In 1859 the work of the Commission to inquire into the condition of the lights, buoys and beacons of the United Kingdom began. Airy and Faraday had charge of the scientific side of the inquiry. Mr. Chance's assistance was called in as a manufacturer of great experience, and it was soon found that in him the Commission had an adviser who could render services of the highest value. His mathematical training enabled him to understand and develop the theory of the subject, his practical experience showed him what was possible. He had already introduced improvements into the method of grinding the annular lenses which form the system, and its various components had reached a high degree of perfection.

But, though this was so, the distribution of light effected by means of the lens system was, in many cases, entirely wrong. At that time Messrs. Chance were not allowed even to tender for the frames to hold the lenses, although they had to make these in order to adjust the system in their workshop. They had no share in the erection or adjustment of the light, which was done usually by contractors with little or no optical knowledge, and the result was failure. One of the most glaring instances was the Whitby light, of which Airy reported:—"The dioptric part of the apparatus is beautiful. The glass is of the best quality. . . ." The adjustments, however, were all wrong.

"My impression is," he writes, "that in the north lighthouse three-fourths of the light is absolutely thrown away, and in the south lighthouse nine-tenths of the light is absolutely thrown away. . . . When with a ruler I covered the part of the flame which merely gave light to the sky, it was absurd to see how little was left for the useful part. . . . It really gave me a feeling of melancholy to see the results of such exquisite workmanship entirely annihilated by subsequent faults in the mounting and adjustment."

In the end, Mr. Chance was given a free hand. Airy again reports, at a later date,

"The said constructor"—Mr. Chance—"is willing to go heartily into the improvement of the Whitby light, therefore leave all others and rest on it."

And this wise advice was taken.

A method of adjustment—it seems sufficiently obvious, and had been used previously—was suggested by Airy and employed in setting up the lenses. Each portion of the lens system is to be employed in forming an image of some part of the lamp flame on the distant horizon or on some part of the sea between the lighthouse and the horizon. Conversely, if the adjustment is correct, a real image of that part of the horizon will be formed by the lens system on the corresponding part of the flame, and can be seen by an observer looking into the lens system from behind.

Airy's method consisted in adjusting the lenses in turn until the image of the horizon formed by each occupied its proper position with regard to the flame.